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"The Potential for the Department of Defense to Use Space-based Remote Sensing to Support DOD and Other Government Agencies' Environmental Programs"

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Introduction

This paper describes the potential for the Department of Defense (DOD) to support other Government agencies in the management of national and worldwide environmental programs while continuing to conduct the traditional role of DOD as the military arm of the Federal Government. The DOD space-based remote sensing program must complement other programs, rather than replace or duplicate those programs. This may include defense-related remote sensing applying technologies to civil applications and environmental functions and ecological information needs; using DOD sensors for civil applications; and expanding the role of the Environmental Task Force (ETF).

Civil (in the context of this discussion) means those functions normally associated with the use of space-based sensors to support the civil works mission of DOD as performed by the U.S. Army Corps of Engineers (USACE). The evolution of the national security role of DOD in the future must address concerns about the environment, the need to maintain technological excellence at minimal cost, and the trend toward joint and cooperative programs with other Government agencies. DOD's traditional role as the military arm of the American people could expand to more closely resemble national considerations that are the purview of the Departments of State and Commerce; e.g., economic stability; clean, safe work environments; and the free interchange of goods and services. DOD will have to address its evolving role in those areas through traditional as well as nontraditional partnerships.

DOD's traditional capabilities in space obviously will continue, but those capabilities will, in all likelihood, have to expand to include new requirements. This may include providing routine assistance to the civil sector for functions such as law enforcement, providing humanitarian relief for natural disasters (e.g., hurricanes) and manmade disasters (e.g., Somalia), and providing support for environmental programs ranging from pollution monitoring to environmental compliance.

Strategy: Cooperative Exploitation of Technology

DOD must consider adopting a strategy which would involve contributing to, using, and exploiting civil space-based remote sensing to satisfy DOD needs as well as to contribute to other agencies' needs. DOD's strategy for the use of space should include:

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- ▼ capitalizing on emerging space systems' capabilities;
- ▼ exploiting space activities that contribute to the successful execution of all DOD missions; and,
- ▼ supporting assured access to space and the use of space capabilities in support of United Nations supported missions.

The DOD space program must maximize cooperative exploitation of non-DOD space programs such as NASA's Mission-To-Planet-Earth (MTPE) program. The MTPE program will provide the scientific basis for understanding global change and is NASA's contribution to the U.S. Global Change Research Program. NASA proposes to accomplish this by orbiting satellites to study the Earth on a global scale and on a continuing basis. In addition to its traditional national security related activities, DOD may have an increased role in fostering cooperative relationships between the U.S. and U.S. agencies (such as NASA) and in supporting civilian government interests in the U.S. and abroad. The future role of DOD in space must emphasize two types of activities to meet future needs:

- ▼ participation in established programs to ensure continuation where there is a potential benefit to DOD or for DOD to support other Government agencies; and,
- ▼ initiation of new technology programs with a high potential for use by DOD to include technology to support the evolutionary development of new DOD missions or mission support activities provided to other Government agencies.

DOD Application of Space-Based Instruments

Table I shows the relationship between DOD applications of space-based instruments and the instruments existing or planned to be on orbit. While these instruments are not inclusive of all space-based sensors that are possible, they are the most likely to exist and are the most likely to have potential utility for DOD. Engineering and Housing Support (EHS), and Training and Testing Lands Applications are distinct functions performed by DOD in support of its nontactical military missions, and include such activities as base construction and repair and training operations support. Table II lists potential civil application areas that DOD, through the USACE, participates in routinely.

Current DOD space-based remote sensing programs have concentrated on achieving traditional DOD national security objectives, while future DOD programs will have to strive to minimize duplication and maximize integration, interoperability and cooperation with other Government agencies' space programs. This may be more difficult to achieve than a clear and singular military

Table I. Space-Based Instruments and DOD Applications		
Space-Based Instrument's Platform or Program (All on-board instruments unless number noted)	DOD Potential Application	
	Civil Applications Support (Civil Works)	Engineering and Housing Support & Training and Testing Lands Applications
MTPE (11)	Yes	Yes
LANDSAT (2)	Yes	Yes
French SPOT (1)	Yes	Yes
European Space Agency Earth Resource Satellite (ERS)-1 (1)	Yes	Probably
Japanese Earth Resource Satellite (JERS)-1	Yes	Probably
Canadian RADARSAT	Yes	Probably
NOAA Polar-Orbiting Environmental Satellite (POES) (1)	Yes	Probably
NOAA Geostationary Operational Environmental Satellite (GOES) (1)	Probably	Unlikely
GPS	Yes	Yes
DMSP	Yes	Yes

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Table II. Potential DOD Civil Application Areas

Aquatic vegetation
Archeological and cultural resources
Assistance to other nations
Construction monitoring
Dam repair
Desertification
Dredging
Drought studies
Emergency operations
Energy usage monitoring
Environmental impact assessments
Environmental monitoring
Erosion studies
Flood control projects
Flood damage assessment
Floodplain
Forestry management
Fuel and chemical spills
Geology and soils studies
Hazardous, toxic, and radioactive wastes
Infrastructure development & relocation
Land cover
Mapping
Natural resource management
Navigation
Pollution monitoring
River/coastal engineering functions
Sedimentation analyses
Sensitive species
Snow cover assessment
Urban area studies
Wetlands delineation

application, but is an absolute necessity to attempt. In the future, DOD space-based remote sensing programs may have to expand their sphere of influence to include civil considerations such as environmental and civil works program support. A report entitled "A Post Cold War Assessment of U.S. Space Policy", published by the Vice President's Space Policy Advisory Board in December 1992, maintains that while there remains a need to maintain distinct civil and national security space sectors, planning should be centralized across sectors and its execution streamlined within the respective sectors. This must be done to foster synergism among the civil, military, intelligence and commercial space-based remote sensing programs. As noted in "A Post Cold War Assessment of U.S. Space Policy" report, delivering

mature, critical technologies to enable space-based remote sensors to meet future requirements, whether tactical military or civil works related, will also require comprehensive and favorable cost and operational effectiveness analyses to support future operational requirements.

Potential DOD Participation in Civil Applications of Space-based Instruments

Analyses must be conducted by DOD to specifically define its role in the post cold war uses of space for other than tactical considerations. In that vein, DOD has initiated several efforts to contribute to some of its space exploitation requirements including:

- ▼ exploiting existing and planned sensors on civil Earth sensing satellites such as LANDSAT, SPOT, and JERS-1;
- ▼ contributing to and focusing research and development (R&D) to support the Space-based Global Change Observation System (S-GCOS) program; and,
- ▼ collaborating and cooperating with the U.S. Navy, NASA, National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), and U.S. Geological Survey (USGS) in requirements definition for space sensors of joint interest.

DOD is in the process of identifying how to assist NASA in their MTPE program. A USACE MTPE task force was formed in March 1991 to determine if and how USACE, as the Army's and DOD's civil works proponent, should become involved in the MTPE program. USACE's interest in the MTPE program is based on the possibility that the MTPE program will measure parameters needed by USACE to support its civil and environmental protection missions. USACE's districts, divisions, and engineering and housing support directorates have a need for remotely sensed imagery, data, and/or information which is currently both expensive and time-consuming to acquire. If space-based, remotely sensed data from the MTPE program can be used to satisfy some of those data needs, the potential for large cost and time savings makes USACE participation in the MTPE program very attractive. The USACE is in the process of preparing a program implementation plan which will:

- ▼ describe how to support the MTPE program and use MTPE data and products for USACE/DOD purposes and
- ▼ identify potential joint or collaborative research and development with NASA and/or NOAA.

Table III shows global change variables being, or planned to be, analyzed for Army purposes.

Table III. Potential U.S. Army Uses of or Contributions to Global Change Variables Using Space-based Instruments

Variables	DMSP (D); POES (P); GOES (G); LANDSAT (L) **
Trace Species:	
H2O	D, P, G
O3	P
Ocean Variables:	
Sea Surface Temperature	D, P, G, L
Sea Ice Extent	D, P, L
Sea Ice Type	D, P, L
Sea Ice Motion	D, P, L
Sea Level	D, P, L*
Atmospheric Response Variables:	
Surface Air Temperature	D, P, G
Tropospheric Temperature	D, P, G
Stratospheric Temperature	D, P, G
Pressure (Surface)	D, P, G*
Tropical Winds	D, P, G*
Tropospheric Water Vapor	D, P, G
Components of Earth Radiation Budget	D, P, G*
Cloud Amount, Type, Height	D, P, G, L
Tropospheric Aerosols	D, P, G*

* Derived utility but not directly measured/observed. Actual usage would be through an all source analysis combining DOD satellite data with other satellite data such as from the GOES, POES, and LANDSAT satellites.

**
D = DMSP, DOD Defense Meteorological Satellite Program;
P = POES, NOAA's Polar-Orbiting Environmental Satellites;
G = GOES, NOAA's Geostationary Operational Environmental Satellites;
L = LANDSAT.

**Table III (Continued). Potential U.S. Army Uses of
or Contributions to Global Change Variables
Using Space-based Instruments**

Variables	DMSP (D); POES (P); GOES (G); LANDSAT (L)
Land Surface Properties:	
Surface Radiating Temperature	D, P, G, L
Snow Cover	D, P, G, L
Snow Water Equivalent	D, P, L
River Runoff (Volume)	P, L
River Runoff (Sediment Loading)	P, L
Surface Characteristics (for albedo, roughness, infrared, and microwave emittance)	D, P, G, L
Index of Land Use Changes (broad classification of vegetation types)	D, P, G, L*
Index of Vegetation Cover	D, P, L*
Index of Surface Wetness	D, P, L*
Soil Moisture	D, P, L, G
Biome Extent, Productivity, and Nutrient Cycling	D, P, L*

The results of those ongoing or planned analyses may contribute to other organizations or agencies programs for global change measurements in many application areas. Table III also shows the current U.S. space-based instrument platforms used to analyze these particular variables. The sensors on the satellites listed on Table III are currently being analyzed, or planned to be analyzed, by the USACE for their potential contributions toward measuring and understanding the global change variables listed on Table III.

Conclusions

Potential new customer relationships may necessitate DOD assuming new and expanded responsibilities, albeit as a supporting partner, to another Government agency. These Governmental partnerships will evolve over time, but are likely to increase in both number and type.

To exploit space, DOD must take advantage or leveraging opportunities when they exist and technology breakthroughs as they occur. This includes adopting commercial techniques, processes, and systems where appropriate. The true measure of success for technology development is the transition of the technology into an operational capability, assuming cost and operational effectiveness analyses warrant the transition.

DOD must continue to monitor and support the work of the ETF in supporting the ecological information needs of the scientific and engineering communities. The report entitled "A Post Cold War Assessment of U.S. Space Policy" noted the need to reduce security constraints associated with national security space program data. The ETF will support that need by determining the applicability of data, products, images and other outcomes that could be used to assist the civil community's need for environmental science data. Environmental stewardship for civil applications is not necessarily a function of the ETF, but it is a strong concern of USACE and is being pursued as aggressively as possible by USACE in each of its civil applications as well as its military responsibilities.

DOD must complement other agencies' space programs, rather than replace or duplicate existing programs. Therefore, two types of activities should be pursued to meet future DOD requirements for other than tactical military applications:

- ▼ more active and visible participation in established, non-DOD programs to enhance DOD capabilities and contributions such as the MTPE program; and
- ▼ direct participation in other programs to ensure continuation where there is a potential benefit to DOD such as the DOD/NASA LANDSAT 7 and follow-on LANDSAT programs.

Recommendations

To support the information needs of the civil sector for global change measurements, the Department of Defense should:

- ▼ continue to support NASA's Mission-To-Planet-Earth by preparing an Earth Observation Program Implementation Plan to help define how to implement DOD, and in particular U.S. Army, participation in the S-GCOS program;
- ▼ participate as an active partner on civil applications working groups to coordinate civil and DOD needs for

environmental data;

▼ continue to support the work of the ETF; and,

▼ consider expanding its role in established, non-DOD space-based remote sensing programs to enhance and improve DOD capabilities and to offer DOD expertise in the conduct of those space programs, while at the same time, being consistent with national security and technology transfer considerations.

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